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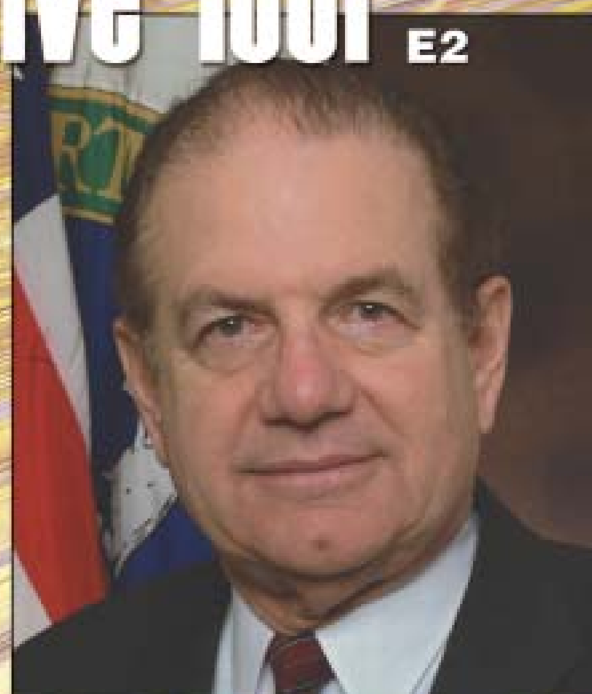
Using Science As a Competitive Tool



Dr. Raymond Orbach,
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Using Science as a Competitive Tool

The federal government has user facilities that help U.S. industry maintain that "unfair advantage" to keep them competitive with their foreign rivals.

There was a time in the not-too-distant past when a very significant amount of truly groundbreaking basic research was performed in U.S.-based industrial research laboratories. Basic research at sites with names like Bell Labs, Xerox-PARC, T.J. Watson, Kendall Square, General Electric, Westinghouse, and Kettering have all either disappeared or been dramatically scaled back. Academia has always been there to perform a part of that function, but they didn't always have the resources, longevity, or adequate funding and surely couldn't pick up the slack that the industrial sector dropped.

That, of course, left the U.S. government with the responsibility to assume a role in the pursuit of basic research. Today, the federal government has appropriated nearly $27 billion for basic research in FY2006. The top three agencies receiving those monies are the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Dept. of Energy's Office of Science (OS). While much of the NIH and NSF funding is targeted at life science research, "the Office of Science has become the world leader in basic research in the physical sciences," says Ray Orbach, Director of the Office of Science in Washington, D.C. "We keep U.S. science in the physical sciences the best in the world."

Orbach is understandably very proud of the science capabilities in the Dept. of Energy. But, he's also very quick to point out the value that these science capabilities provide to the long-term economic health of the U.S. While the NIH and NSF mainly act as aqueducts for the funneling of monies to various research universities and organizations, the OS actually provides the unique facilities along with the funding for basic research across a wide range of disciplines, including the life sciences.

"The Dept. of Energy is charged with a broad spectrum of responsibilities," says Orbach. "To meet those responsibilities, we have to maintain strong interrelationships between our basic research and our applied science work. It's the applied science that actually solves the problems we're faced with, but it's the basic research that comes up with the ideas that feeds into the applied science on ways to solve the problems—it's a strong two-way street."

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For example, the Dept. of Energy has a very serious cleanup problem in Hanford, Wash., with potentially leaking tanks holding radioactive waste from the creation of nuclear weapons over the past 50 years. "We're trying to predict the behavior of a possible radioactive liquid plume beneath the tanks to see if the plume will reach the Columbia River," he says. "We're looking at what happens in the region above the water table—the vadose zone. This is a very interesting computational problem where we're feeding applied science readings collected from drill cores beneath the tanks to a software model—a good example of basic research feeding into an applied research problem."

Using science to compete

"My philosophy is that our scientists aren't any smarter than any other scientists in the world," says Orbach. With the continuing improvements in the standards of living worldwide, enhancements in foreign universities, exchange student relationships, and accelerating communications, there is a continuing leveling of trained scientists and engineers throughout the world. "But science is inextricably linked to a country's economy, and the U.S. has the best science resources in the world. We can conduct large scale experiments better than anyone else." This gives a competitive edge to a potentially equal skill level that is difficult to overcome.

The facilities that Orbach refers to are not trivial. They start at $50 million each and often go into the hundreds of millions and even billions of dollars of investment. They also take a long time to implement. "It generally takes more than eight years to build anything," says Orbach. But the payback for these facilities has been tremendous. An examina-

A Look at Science's Future

Much of the U.S.'s research and innovation has been and continues to be linked to "big science" facilities—those facilities that are too large, expensive, and complex for any company or university or even group of companies and universities to afford. The breadth and depth of these facilities have become a sort of national treasure of scientific endeavor that is unmatched by any other single country. While built to serve one scientific field, most have made significant contributions to knowledge and technology in other fields, including biology and medicine.

The U.S. Dept. of Energy, through a variety of means, has become the holder and operator of many of these facilities that mostly reside at their broad system of national laboratories. You immediately become aware of the scale of these facilities by their descriptions, which generally include phrases like the world's "largest, fastest, most-powerful, brightest, or strongest." Many of these facilities are also termed as user-facilities, meaning that companies, academics, and other government researchers can use them for ridiculously inexpensive rates—the rates definitely are not considered as a fee meant to pay back the initial investment cost.

The usefulness of many of these facilities is often keyed to their age and capabilities, with continuing upgrades and new construction mostly coming in splurts when specific needs are recognized or new discoveries unveiled. In late-2003, the Dept. of Energy released a roadmap for its "Facilities for the Future of Science."

In late-2003, the Dept. of Energy revealed its plan for "Facilities for the Future of Science." The prioritized 28 large-scale facilities and upgrades outlined in this report, which was created by six DOE Office of Science Advisory Committees (and prioritized by Orbach) are expected to provide new opportunities to scientists over the next 20 years. A list of the facilities is provided below. For a more detailed description of each facility and the protocols used to create this list, go to www.science.doe.gov/sub/Facilities_for_future/facilities_future.htm.

Facilities for the Future of Science

Priority	Facility	Likely Location
1	ITER	Cadarache, France
2	UltraScale Scientific Computing	Multiple sites
3	Joint Dark Energy Mission	Space probe with NASA
3	Linac Coherent Light Source	TBD
3	Protein Production and Tags	TBD
3	Rare Isotope Accelerator	Argonne Lab
7	Characterization and Imaging	TBD
7	CEBAF Upgrade	Thomas Jefferson Lab
7	ESnet Upgrade	Multiple sites
7	NERSC Upgrade	Lawrence Berkeley Lab
7	Transmission Electron Achromatic Microscope	TBD
12	BTeV	Fermi Lab
13	Linear Collider	TBD
14	Analysis and Modeling of Cellular Systems	TBD
14	SNS 2-4 MW Upgrade	Oak Ridge Lab
14	SNS Second Target Station	Oak Ridge Lab
14	Whole Proteome Analysis	TBD
18	Double Beta Decay Underground Detector	TBD
18	Next-Step Spherical Torus	TBD
18	RHIC II	Brookhaven Lab
21	National Synchrotron Light Source Upgrade	Brookhaven Lab
21	Super Neutrino Beam	TBD
23	Advanced Light Source Upgrade	Berkeley Lab
23	Advanced Photon Source Upgrade	Argonne Lab
23	eRHIC	Brookhaven Lab
23	Fusion Energy Contingency	TBD
23	HFIR Second Cold Source and Guide Hall	Oak Ridge Lab
23	Integrated Beam Experiment	TBD

tion of many of these facilities reveals that most are booked solid for run time by the elite of the academic and industrial research community. Pharmaceutical companies, chemical and polymer materials companies, and environmental scientists continue to compete for machine time to better understand the materials they're trying to develop. The richness of the capabilities that these machines provide are often only available at one other location in Asia or one in Europe, and sometimes there are no competitors at all.

The most recently constructed OS science facility is the Spallation Neutron Source (SNS) at Oak Ridge National Laboratory in Tennessee. One of five OS-funded national nanotechnology centers is being built alongside the SNS to take advantage of its high-energy beam line to examine new nanomaterials. (The other nanotech centers are being built at Argonne, Berkeley, Sandia/Los Alamos, and Brookhaven for similar relational reasons.) The SNS is the last major facility currently scheduled to be built by the DOE.

To determine the future of these type facilities, Orbach was involved in the creation of a 20-year science facility roadmap in late-2003 (see sidebar). Two years now into this roadmap, the first three of these prioritized projects are already in progress. How the remainder of the roadmap plays out will obviously depend upon the ability and commitment of the government to support the long-term aspects of a basic research science foundation.

That said, the proposed facilities in the roadmap are similarly non-trivial, each represents a major commitment in time, money, manpower, and development. Two of the projects proposed, for instance, are upgrades to the SNS, which is just now nearing completion itself.

Hardware alone won't win the race

Orbach admits that just providing strong hardware facilities alone is not enough to guarantee a continuing strong economy. He refers to the recent National Academy of Sciences

Federal Science Budgets

(Billions of dollars)

	FY2005 Basic Research	FY2005 All Research	FY2006 Basic Research	FY2006 All Research	Change
National Institutes of Health	15.111	27.487	15.242	27.909	1.5%
National Science Foundation	3.416	3.695	3.510	3.791	2.6%
Dept. of Energy, Off of Science	2.787	2.787	2.851	2.851	2.3%
Total U.S. Government	26.855	55.976	26.593	57.148	2.1%

Source: AAAS

report, "Rising Above the Gathering Storm," which was chaired by former Lockheed Martin CEO Norman Augustine, as evidence that the U.S. faces critical challenges in its support of science and technology. "All of the factors stated in the Augustine report relating to the U.S. standing in science and technology were negative compared to other countries. Recommendations in the report include:

- Increasing America's talent pool by improving science and math education,
- Strengthening government support of long-term basic research,
- Making America more attractive to scientists and engineers
- Modernizing the innovation system in America.

"The U.S. has played a winning game for a long time, but we're now in danger of losing our leadership in science, says Orbach. "It is extremely important to maintain the U.S. lead in science." Orbach doesn't find it difficult at all, when confronted with the realities of balancing the science needs of his department with the budget provided by the Congress. "All I have to do is state that we want to maintain our science leadership and we don't want to be second to anyone." There are few budget managers willing to argue with those sentiments.

Even with today's large budget deficit and the Iraq war, Orbach doesn't see the funding of science by the government as more difficult to obtain that it was in the mid- to late-1990s. Whenever confronted with budgetary issues, all he has to do is point to the many successes that the science facilities have produced. From the development of the Internet more than 30 years ago to starting work on the Human Genome Project nearly 20 years ago to enhancing national security with the development of advanced sensors, the OS science facilities have "expanded the frontiers of discovery." They've also been directly responsible for the winning of 13 Nobel prizes, and the discovery of all but one (the electron) of the most fundamental constituents of matter (quarks and leptons).

Looking ahead

When asked what he feels will change the most over the next five years at the Dept. of Energy, Orbach responded quickly that the agency will be recognized for its best practices. Orbach and the Dept. of Energy overall have taken on very seriously the "awesome responsibility to feed science and technology into the U.S. economy." The industrial labs are gone, and "all we have left is the complex of DOE national labs," he says. People are beginning to recognize that the DOE is a well-managed, important agency. Orbach has put in place a number of programs for enhancing the safety of the labs (safety records have improved two to three times over the past two years), and for appraising the individual performance of each laboratory, a report card so to speak. "In some cases, we haven't told the labs how to go about improving their systems; we've just told them to make improvements. In other cases, we're putting formal evaluation programs in place."

Orbach is also very supportive of what he refers to as the triad of basic research providers in the U.S. government—the NIH, NSF, and the OS. This organization provides a diversity of basic research support that's not seen in other countries. "Research at the NSF and NIH is proposal driven, while our research is mission driven," he says. "Similar research at NASA is generally driven by the National Academy of Sciences. This overall pluralism of basic research activities works to advance and support science in the U.S."

—Tim Studt

Office of Science Bits and Bytes

The Dept. of Energy's Office of Science has five interdisciplinary program offices:

- Advanced Scientific Computing Research
- Basic Energy Sciences
- Biological and Environmental Research
- Fusion Energy Sciences
- High Energy Physics and Nuclear Physics

The Office of Science also manages 10 laboratories.

Five are multiprogram facilities:

- Argonne National Laboratory, Ill.
- Brookhaven National Laboratory, Upton, N.Y.
- Lawrence Berkeley National Laboratory, Calif.
- Oak Ridge National Laboratory, Tenn.
- Pacific Northwest National Laboratory, Richland, Wash.

Five are single-program facilities:

- Ames Laboratory, Iowa
- Fermi National Accelerator Laboratory, Batavia, Ill.
- Thomas Jefferson National Accelerator Laboratory, Newport News, Va.
- Princeton Plasma Physics Laboratory, N.J.
- Stanford Linear Accelerator Center, Calif.
- Offices of Science user facilities are used by more than 19,000 researchers/yr.
- About 50% of the Office of Science budget supports research by more than 23,500 researchers at more than 250 universities.
- The Office of Science supports the National Science Bowl, attracting more than 12,000 high school student participants.